ters of excellence to supplement their existing core strengths (Patel and Vega 1999).

According to a study of 238 foreign R&D sites, 45 percent of the labs were home-base augmenting and 55 percent were home-base exploiting (Kuemmerle 1997).[58]

U.S. and Foreign Industrial R&D Expenditure Balance

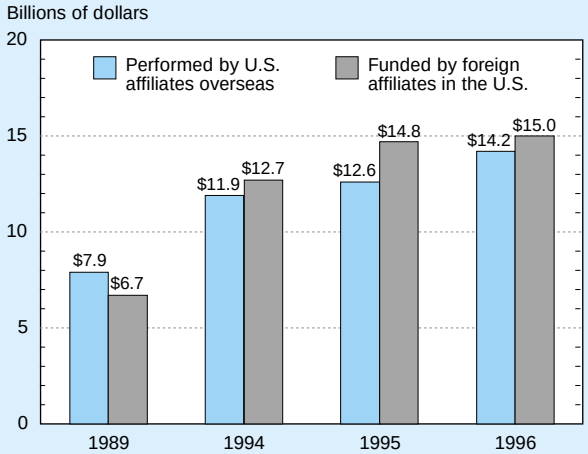
U.S. companies' R&D investments abroad are roughly equivalent to R&D expenditures in the United States by majority-owned U.S. affiliates of foreign companies.[59] In 1996 (the latest year for which complete data from the Bureau of Economic Analysis [BEA] are available at this writing), industrial R&D flows into the United States totaled $15.0 billion, compared with $14.2 billion in R&D expenditures by U.S. multinational firms in other countries. (See figure 2-37.) This approximate balance in R&D investment flows has persisted since (at least) 1989, when the majority-owned data first became available on an annual basis. In 1989, however, U.S. companies conducted a greater amount of R&D abroad than was invested in the United States by foreign firms. The reverse now appears to be true: More industrial R&D money is flowing into the United States than U.S. firms are performing abroad. Whatever the exact "balance" in any given year, however, higher levels of U.S. R&D investment in foreign economies and non-U.S. R&D investment within the U.S. domestic economy clearly are becoming the norm (Mowery 1998a).

Europe is the primary source and the main location of performance of these U.S.-foreign industrial R&D flows. (See figure 2-38.) European firms invested $11.2 billion of R&D money in the United States in 1996; the Asian (excluding the Middle East) and Pacific region provided the second largest source of foreign R&D funds ($1.9 billion). Similarly, foreign affiliates of U.S. companies performed $9.7 billion of R&D in Europe and $2.1 billion in Asia and the Pacific region.[60] Industrial R&D investments between Canada and the United States are in the $1.5 billion range. U.S. industry's R&D flows remain relatively small (less than $1 billion) into and out of Latin America and the Middle East and are negligible with Africa.

[58]The terms "home-base exploiting" and "home-base augmenting" are taken directly from Kuemmerle (1997). Others, however (e.g., Mowery 1998b and Dalton, Serapio, and Yoshida 1999), have made similar observations on the reasons for expanding global R&D arrangements. Furthermore, Mowery notes that the use of international R&D strategies to establish networks for the creation and strengthening of firm-specific technological capabilities (i.e., home-base augmenting) is likely to become more important than market exploitation-driven activities in the future.

[59]These overseas R&D data are from the BEA survey on U.S. Direct Investment Abroad. The definition used by BEA for R&D expenditures is from the Financial Accounting Standards Board Statement No. 2; these expenditures include all charges for R&D performed for the benefit of the affiliate by the affiliate itself and by others on contract. BEA detail is available for 1982 and annually since 1989. Data on foreign sources of industrial R&D performed in the United States come from an annual survey of Foreign Direct Investment in the United States, also conducted by BEA. BEA reports that foreign R&D totals are comparable with U.S. R&D business data published by NSF. Industry-specific comparisons, however, are limited because of differences in the industry classifications used by the two surveys (Quijano 1990).

Figure 2-37.
Globalization of U.S. industrial R&D



NOTE: Data for majority-owned (50 percent or more) non-bank affiliates only.

See appendix tables 2-69 and 2-71.

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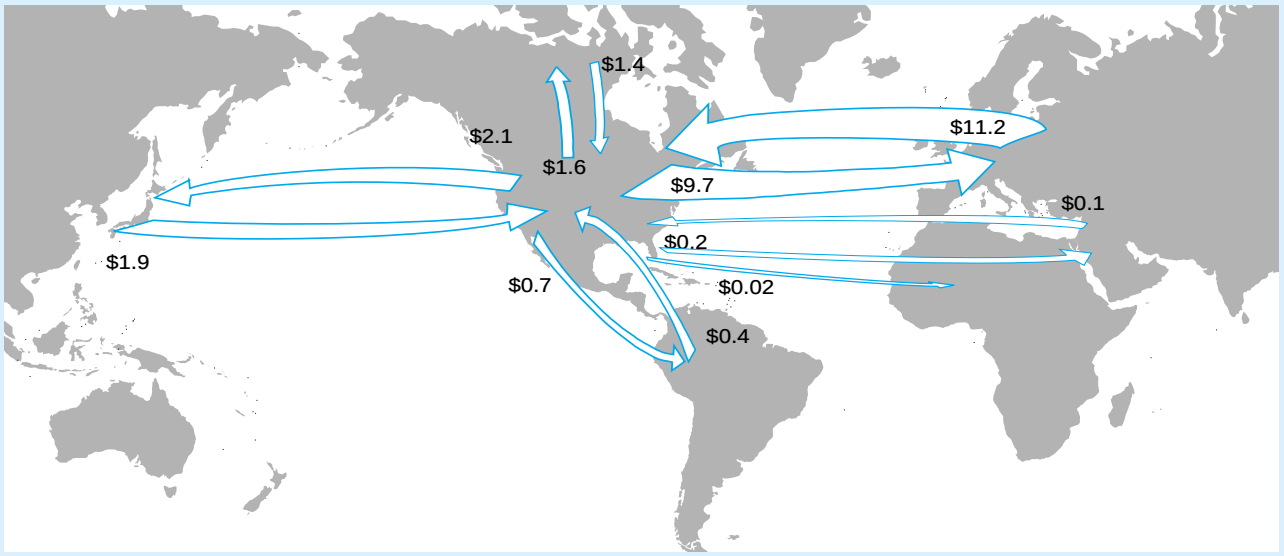
Trends in U.S. Industry's Overseas R&D

From 1985 through 1996, U.S. firms generally increased their annual funding of R&D performed outside the country more than their funding of R&D performed in the United States. (See appendix table 2-68.) Indeed, during this period U.S. firms' investment in overseas R&D increased 2.8 times faster than did company-funded R&D performed domestically (9.7 percent versus 3.4 percent inflation-adjusted average annual growth). Overseas R&D funding accounted for about 6.0 percent of U.S. industry's total (domestic plus overseas) R&D funding in 1985; in 1996 overseas R&D accounted for 10.4 percent of U.S. industry's total R&D. In 1997, however, strong growth in U.S. companies' domestic R&D financing (up 10 percent), coupled with a 7 percent decline in

[60]Analyses of the BEA data on overseas R&D activities of U.S. affiliates have become complicated as a result of a change in survey collection. Prior to the 1994 survey, BEA collected expenditure data on R&D funding by U.S. overseas affiliates regardless of whether the R&D was performed by the affiliate of by others. It excluded R&D conducted by the affiliate under contract for others. Beginning with the 1995 survey, U.S. affiliates were asked to report their R&D performance irrespective of the funding sources (i.e., they report R&D conducted in their own labs, including R&D funded by the affiliate itself and by others under contracts). R&D funded by the U.S. affiliate but conducted by other organizations are excluded. Consequently, the more recent BEA figures represent R&D performance of U.S. firms' foreign affiliates and not the foreign R&D funding made by U.S. firms.

Figure 2-38.
Industrial R&D of U.S. and foreign affiliates, by world region: 1996

Billions of dollars



See appendix tables 2-69 and 2-71.

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industry's overseas R&D spending, reduced the overseas share to 8.9 percent of U.S. companies' funding total.[61]

Additionally, according to BEA data, the majority-owned (that is, 50 percent or more) foreign-affiliate share of U.S. multinational companies' worldwide R&D expenditures increased from 9 percent in 1982 to 13 percent in 1990, where it remained through 1994 (Mataloni and Fahim-Nader 1996). According to preliminary data for 1996, the foreign-affiliate share of U.S. multinationals' total R&D funding rose to 14 percent (Mataloni 1998).

Sector Focus of Overseas R&D Activity

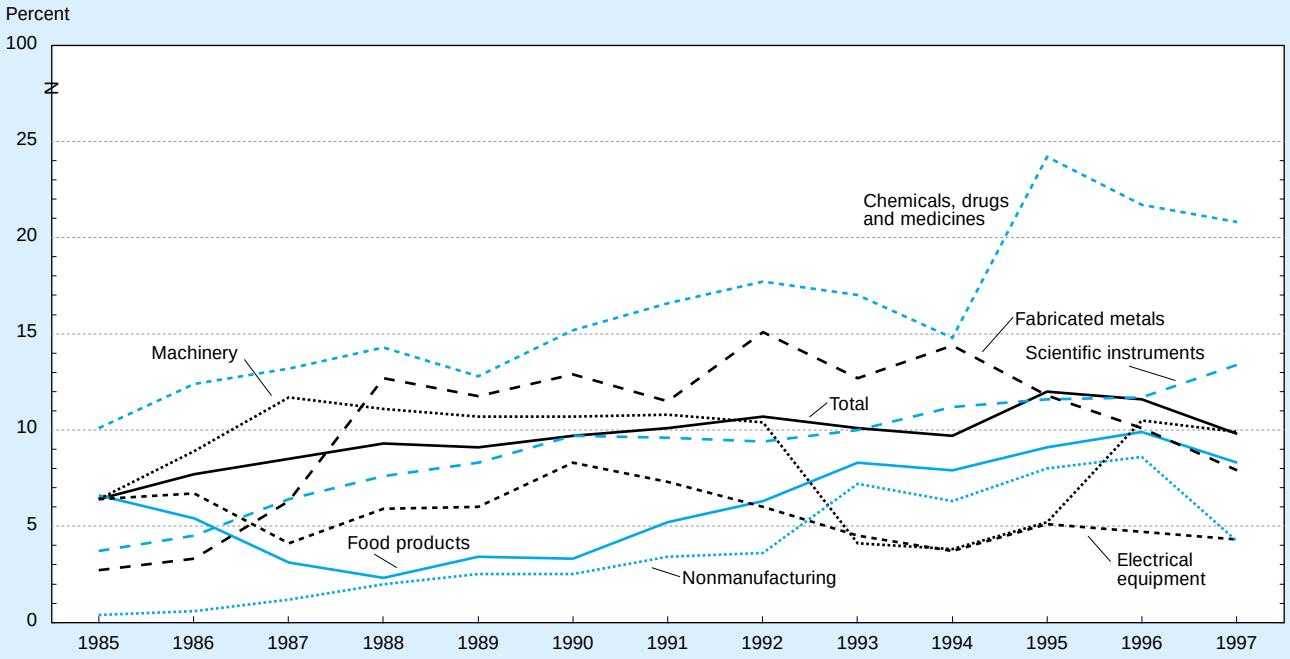
R&D investment by U.S. companies and their foreign subsidiaries in the chemicals (including pharmaceuticals and industrial chemicals) industry accounts for the largest share and greatest growth of foreign-based R&D activity. (See figure 2-39.) Indeed, drug companies accounted for 18 percent of total 1997 overseas R&D ($2.4 billion of the $13.1 billion total)—equivalent to 21 percent of the pharmaceutical industry's domestically financed R&D. Part of this growth undoubtedly is a function of the worldwide pattern of collaboration between integrated global pharmaceutical firms and emerging biotechnology companies in the U.S. and Europe—most notably the United Kingdom (Council on Competitiveness 1998). (See appendix table 2-68.)

Similarly, firms in the industrial and other chemicals industry spent an amount overseas ($1.5 billion) equivalent to 21 percent of their onshore R&D investment. Demand and supply factors alike seem to be driving this internationalization. R&D is performed overseas so that global firms are better able to customize their products to meet the needs of local customers and to ensure market access. Furthermore, chemicals R&D performance is becoming global because different regions of the world are becoming technologically specialized—Germany, for example, in fundamental research in organic synthesis and Japan in electronic chemicals (Arora and Gambardella 1999). Of other major R&D-performing manufacturers, recent trends show the overseas R&D investment share of total R&D financing rising considerably for scientific instruments ($1.2 billion in 1997, equivalent to 13 percent of the domestic total) and machinery equipment ($1.8 billion in 1997, equivalent to 10 percent of the domestic total).

Growth in overseas R&D investments is not limited to sectors with strong historical experience in overseas production activity. The combined total for all nonmanufacturing industries indicates substantial increases in foreign R&D activity since 1985—rising from 0.4 percent of domestic R&D funding that year to 8.6 percent in 1996. Part of this growth reflects increased international R&D financing by firms historically classified as nonmanufacturing industries

[61]These overseas R&D shares are taken from the NSF industrial R&D data series, not the BEA Direct Investment Abroad series used in the "U.S. and Foreign Industrial R&D Expenditure Balance" discussion. However, BEA data on the country destination of the U.S. overseas R&D investment are more complete than the NSF series and therefore are used to describe country patterns. NSF reports 1996 and 1997 overseas R&D totals of $14.1 billion and $13.1 billion, respectively; BEA estimates 1996 overseas R&D performance by foreign affiliates of U.S. companies (including both for the affiliate and for others) at $14.2 billion.

Figure 2-39.
Ratio of U.S. overseas R&D to company-financed domestic R&D



See appendix table 2-68.

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(particularly computer, data processing, and architectural services). Part of the increase reflects the movement of firms previously classified as manufacturers (e.g., office computing companies) to service sector industries (e.g., software development). This observation is borne out by the reduction in nonmanufacturers' overseas R&D in 1997 ($1.4 billion, down from $2.5 billion in 1996). Most of this decline reflects firms' shifting industry classifications within IT-related industries rather than an actual drop in industrial funding activity. Nonetheless, overseas R&D investments in information technologies remain substantial. One factor driving such globalization is that foreign labor markets provide U.S. companies with an ample supply of qualified (and sometimes less-expensive) science and engineering personnel—as indicated by robust IT investments in English-speaking India, Ireland, and Canada.[62] (See chapter 3 on the Science and Engineering Workforce and chapter 9 on the Significance of Information Technologies.)

Country Location of U.S. Overseas R&D Activity

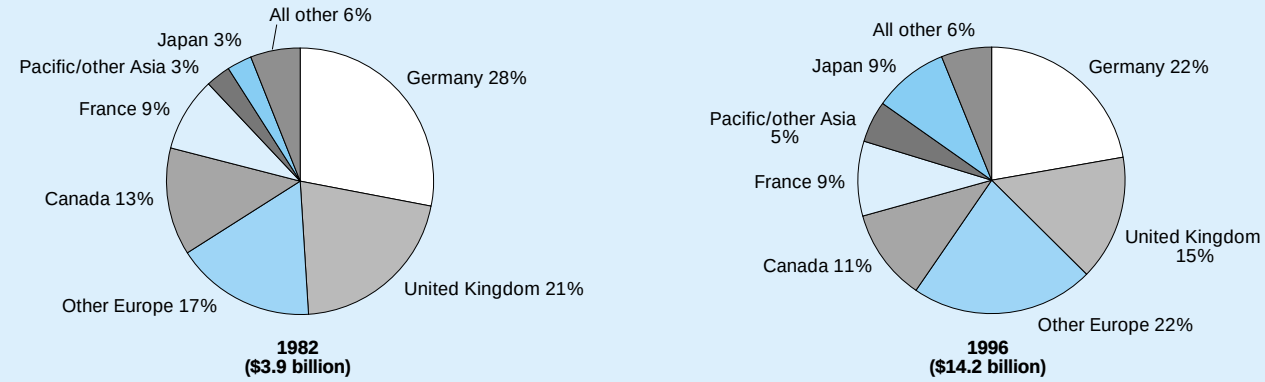
As BEA data on majority-owned foreign affiliates of nonbank U.S. multinational companies indicate, most of the U.S. 1996 overseas R&D was performed in Europe—primarily Germany (22 percent of the U.S. overseas total), the United Kingdom (15 percent), and France (9 percent). (See figure 2-40 and appendix table 2-69.) Collectively, however, the current 68 percent European share of the U.S. total R&D investment abroad is less than the 75 percent share reported for 1982. Since the early 1980s, U.S. R&D investments abroad have generally shifted from the larger European countries and Canada toward Japan, several of the smaller European countries (notably Sweden and the Netherlands), Australia, and Brazil.

As indicated by affiliate industry classifications, U.S. R&D investments abroad are concentrated in specific geographic locations. Almost half of the offshore automotive R&D in 1996 was spent in Germany; spending by transportation equipment companies accounted for almost two-thirds of all U.S. affiliate R&D activity in Germany. In the United Kingdom, France, Japan, and Italy, the chemicals industry accounted for the largest share of each country's respective R&D totals; collectively these four countries accounted for 54 percent of all U.S. affiliates' chemicals-related R&D. Electrical equipment firms accounted for most of the U.S. affiliates' R&D performance in the Netherlands; except for Germany, no other country accounted for more of the U.S. affiliates' electrical equipment R&D than did this relatively small country. (See text table 2-19.) These industry R&D emphases reflect the general industrial strengths of the various countries.

After Germany ($3.1 billion) and the United Kingdom ($2.1 billion), Canada is the next-largest site of U.S. overseas R&D performance. Almost $1.6 billion was spent in major-

[62]For an informative discussion on the internationalization of R&D in Canada, see Anderson and Gault (1999). The information and communications sector now appears to account for 69 percent of the total foreign R&D funding provided Canada's industrial sector.

Figure 2-40.
U.S. R&D performed abroad



See appendix table 2-69.

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Text table 2–19.
R&D performed overseas by majority-owned foreign affiliates of U.S. parent companies, by selected country and industry of affiliate: 1996 (millions of U.S. dollars)

Country	All industries	Manufacturing					Nonmanu-facturing
		Total	Chemicals	Machinery	Electrical equipment	Transportation equipment	
Total	14,181	12,358	3,700	1,063	1,258	4,252	1,823
Canada	1,582	1,457	302	28	97	D	125
Europe	9,651	8,625	2,715	746	749	2,894	1,026
Belgium	369	299	197	3	3	33	70
France	1,326	1,169	658	85	47	90	157
Germany	3,061	2,916	279	234	209	1,939	145
Italy	553	D	267	59	54	57	D
Netherlands	545	382	101	9	149	17	163
Spain	317	298	75	5	34	D	19
Sweden	439	404	D	22	9	*	35
Switzerland	189	134	29	D	D	–	55
United Kingdom	2,133	1,860	682	262	69	D	273
Rest of Europe	719	D	427	67	D	D	D
Asia and Pacific	2,073	1,582	552	262	220	D	491
Australia	409	318	85	D	1	D	91
Japan	1,337	1,002	405	184	132	2	335
Rest of Asia/Pacific	327	262	62	D	87	D	65
Western hemisphere	687	647	106	15	189	276	40
Brazil	489	482	61	10	D	D	7
Mexico	119	100	17	5	D	D	19
Middle East (Israel)	166	28	13	10	3	0	138
Africa	21	19	12	3	*	0	2

D = withheld to avoid disclosing operations of individual companies; * = less than $500,000

NOTES: Includes direct investments of majority-owned nonbank foreign affiliates of U.S. parents. Includes R&D expenditures conducted by the foreign affiliates for itself or for others under a contract.

SOURCE: U.S. Bureau of Economic Analysis, U.S Direct Investment Abroad (Washington, DC: BEA, 1998)

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ity-owned Canadian affiliates of U.S. firms. These considerable R&D investments are consistent with the overall facts that these two countries are one another's most important trade partners and that the level of U.S. investment in Canada is among the highest anywhere in the world. Unfortunately, disclosure restrictions to protect the confidentiality of specific firms' underlying R&D expenditures limit the amount of publishable data about the industries in which this considerable U.S. investment is being made.

Industry-wide, nonmanufacturing industries (including business services, with $0.9 billion) now account for 13 percent ($1.8 billion) of U.S. overseas R&D performance. Of this amount, majority-owned Japanese affiliates of U.S. multinational firms accounted for the largest single country share. (See text table 2-19.)

U.S. Industry's Overseas R&D Facilities

The U.S. Department of Commerce recently compiled data on R&D facilities located abroad (Dalton, Serapio, and Yoshida 1999). Although the information is based largely on secondary sources and is at best a sample of such activities, it nonetheless is illustrative of patterns in the establishment of U.S. R&D facilities overseas. There were 186 known foreign R&D facilities owned by 85 U.S. companies in 22 countries in 1997.

The list of U.S. facilities by country is similar to the list of countries in which U.S. firms spend the largest amounts of R&D investments abroad. Japan leads all countries as the site of U.S. R&D facilities (43), followed by the United Kingdom, Canada, France and Germany. As with foreign-owned facilities located in the United States (see "U.S. Research Facilities of Foreign Firms"), the largest number of U.S.-owned foreign facilities support the automotive (32 facilities), drugs and biotechnology (28), computers (25), and chemicals and rubber (23) industries. Although the data are not conclusive, U.S. firms have chosen to locate facilities in Japan to serve a variety of chemicals, drugs, automotive, and computer R&D needs. (See text table 2-20.)

The mix of industries represented by facility sites in major host countries is quite diverse.[63] For example, in the automotive and drug/biotechnology industries, U.S. firms own three or more facilities in five or more countries. Additionally, several emerging countries have been chosen as important locations for U.S. firms' R&D facilities. The most notable examples are Singapore (which now hosts 13 U.S.-owned facilities), Taiwan, and India—each of which has attracted relatively high levels of foreign R&D and created high-technology centers in their countries. Although China and Russia have been mentioned as potential future sites for U.S. R&D investments, protection of intellectual property remains a major concern that may limit such growth.

Motives for establishing overseas R&D facilities are manifold and differ among industries; technology or supply-oriented reasons have increasingly influenced the decision of U.S. firms to locate R&D abroad (a home-base augmenting strategy). This trend is particularly true for electronics and computer software. Even when companies initially invested abroad for the purpose of assisting their manufacturing/sales/service facilities in a local market (a home-base exploiting strategy), they increasingly are positioning these R&D facilities as regional R&D bases (Dalton, Serapio, and Yoshida 1999).

[63]The figures in text table 2-20 represent only counts of facilities, however. The facilities themselves differ considerably in terms of dollars spent and scientists and engineers employed. More detailed information about the individual sites would permit a clearer determination of industry clustering and decentralization.

Text table 2–20.
U.S. R&D facilities abroad: 1997

Industry	Japan	United Kingdom	Canada	France	Germany	Others
Total	43	27	26	16	15	55
Automotive	6	4	4	4	5	9
Computers	7	5	0	1	2	10
Software	4	1	1	0	0	6
Semiconductors	4	1	0	1	0	6
Opto-electronics, telecom	2	0	2	2	1	6
Other electronics	3	2	2	1	1	2
Drugs, biotechnology	8	5	4	3	3	5
Chemicals, rubber	9	1	2	2	2	7
Other transportation equip	0	0	3	0	0	0
Metals, petroleum refining	0	2	6	0	0	6
Instrumentation, medical devices	0	5	3	0	0	2
Food, consumer goods, misc	1	3	4	2	0	5

NOTE: "Other countries" include 13 facilities in Singapore, 11 in China, and 8 in Belgium. These data are derived from secondary sources and are therefore a sample of the total (unknown) number of R&D facilities. The industry-specific detail may double-count some facilities because of the multiple focus of research performed. Not all industry categories are listed. The country totals do not include double-counting.

SOURCE: U.S. Department of Commerce, *Globalizing Industrial Research and Development*, by D. H. Dalton and M. G. Serapio, and P.G. Yoshida. Washington, DC, 1999.